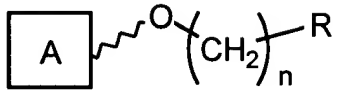
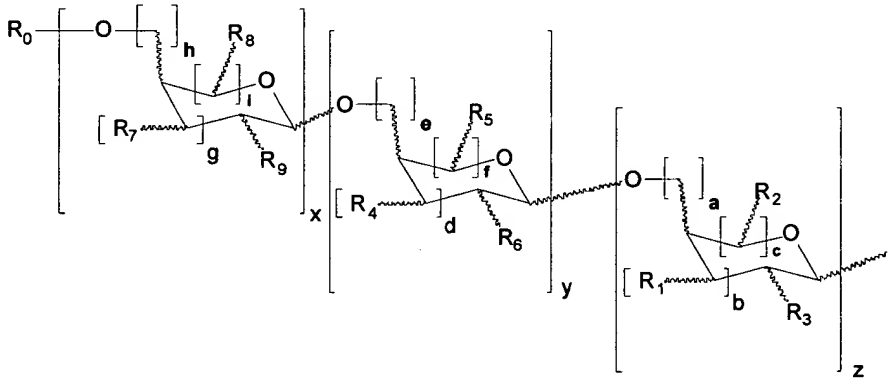
Claims

1. A compound having the structure:

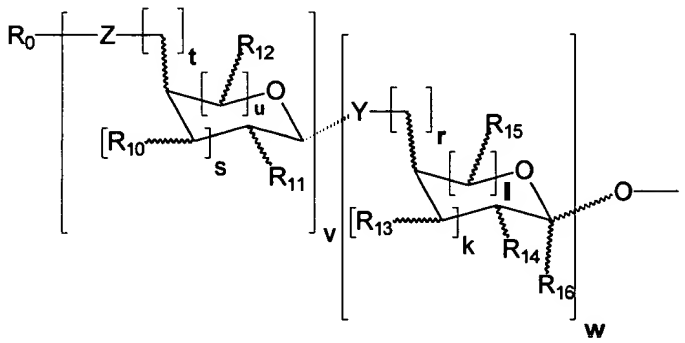


wherein R is hydrogen; substituted or unsubstituted alkyl; alkenyl; aryl; $-CH_2CH(CO_2R')(NHR'')$, wherein R' or R'' are each indpendently hydrogen, protecting group, substituted or unsubstituted alkyl, a linker, aryl, peptide, protein or lipid; or NHR''', wherein R''' is a protein, peptide, or lipid linked to N directly or through a crosslinker; wherein n is 0-8; and wherein A is a carbohydrate domain having the structure:



wherein a, b, c, d, e, f, g, h, i, x, y and z are independently 0, 1, 2 or 3, with the proviso that x, y and z are not simultaneously 0; wherein R_0 is hydrogen, a linear or branched chain alkyl, acyl, arylalkyl or aryl group; wherein R_1, R_2, R_3, R_4 , R_5, R_6 , R_7, R_8 and R_9 are each independently hydrogen, OH, OR^i, NH_2, $NHCOR^i$, F, CH_2OH, CH_2OR^i, a substituted or unsubstituted linear or branched chain alkyl, (mono-, di- or tri)hydroxyalkyl, (mono-, di- or tri)acyloxyalkyl, arylalkyl or aryl group; wherein R^i is

hydrogen, CHO, $COOR^{ii}$, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group or a saccharide moiety having the structure:



wherein Y and Z are independently NH or O; wherein k, l, r, s, t, u, v and w are each independently 0, 1 or 2; wherein R_{10}, R_{11}, R_{12}, R_{13}, R_{14} and R_{15} are each independently hydrogen, OH, OR^{iii}, NH_2, $NHCOR^{iii}$, F, CH_2OH, CH_2OR^{iii}, or a substituted or unsubstituted linear or branched chain alkyl, (mono-, di- or tri)hydroxyalkyl, (mono-, di- or tri)acyloxyalkyl, arylalkyl or aryl group; wherein R_{16} is hydrogen, COOH, $COOR^{ii}$, $CONHR^{ii}$, a substituted or unsubstituted linear or branched chain alkyl or aryl group; wherein R^{iii} is hydrogen, CHO, $COOR^{iv}$, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group; and wherein R^{ii} and R^{iv} are each independently H, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group, with the proviso that if A is KH-1, N3, Globo-H, glycophorin, Tn, TF, STN, (2,3)ST, 2,6-STn or Le^y, and A is α-O-linked, then n is at least 1.

2. The compound of claim 1, wherein R is allyl.

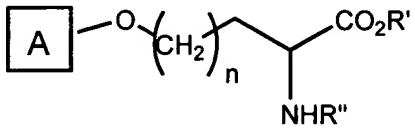
3. The compound of claim 1, wherein n is 1 and R is allyl.

4. The compound of claim 1, wherein n is 2, and R is allyl.

5. The compound of claim 1, wherein R is NHR'", and wherein the protein R'" is KLH or Bovine Serine Albumin, whereby said compound is a glycoconjugate.

6. The compound of claim 1, wherein R is NHR'", and wherein the lipid R'" is PamCys, whereby said compound is a glycoconjugate.

7. The compound of claim 1, wherein R is $CH_2CH(CO_2R')(NHR")$ and the resulting glycopeptide has the structure:



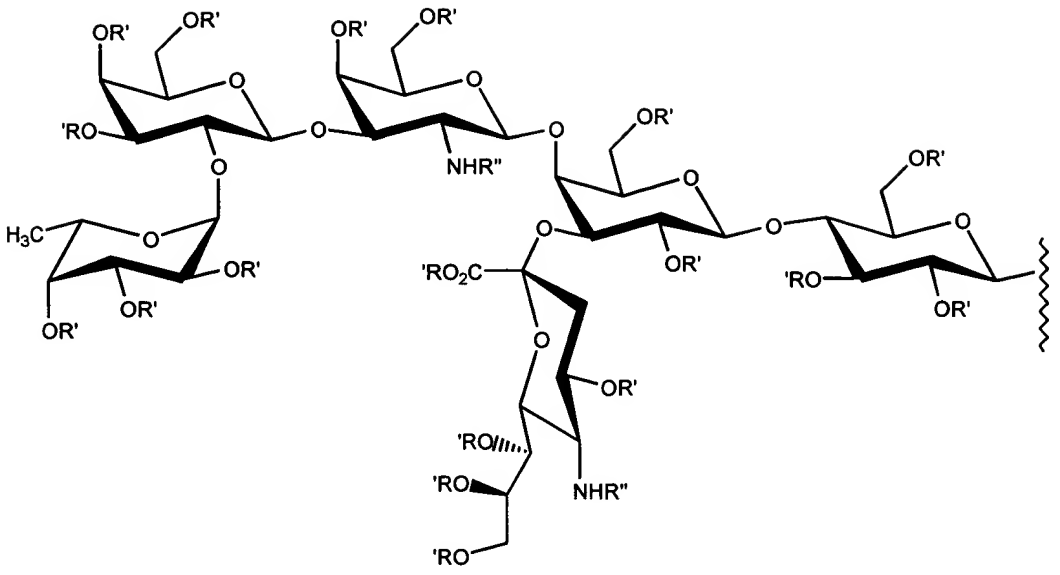
8. The compound of claim 7 wherein n is 3.

9. The compound of claim 7, wherein R' and R" are each hydrogen or a protecting group.

10. The compound of claim 9, wherein R' and R" are each protecting groups independently selected from the group consisting of Fmoc, acetyl, Boc, *t*-butyl and TSE.

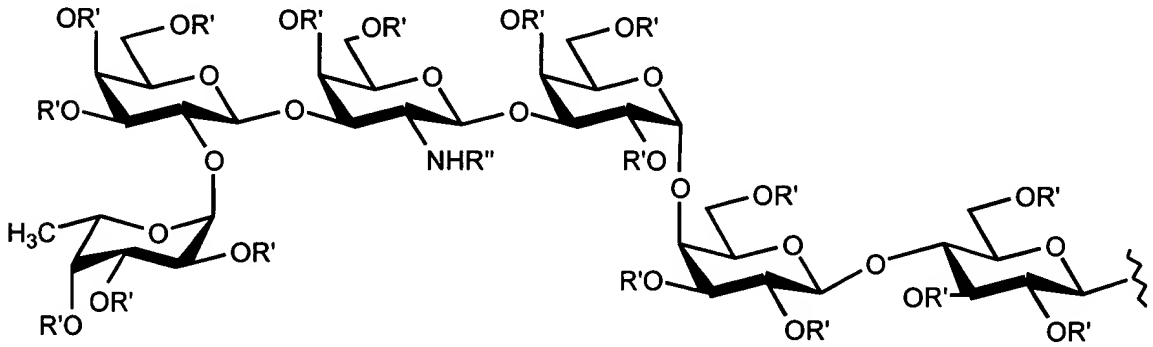
11. The compound of claim 1, 4, 7 or 8, or the glycoconjugate of claim 5 or 6, wherein the carbohydrate determinant is selected from the group consisting of Globo-H, fucosyl GM1, KH-1, glycophorin, N3,Tn, TF, STN, (2,3)ST, 2,6-STn, and Le^y.

12. The compound or glycoconjugate of claim 11, wherein A is the carbohydrate determinant fucosyl GM1 having the structure:



wherein each occurrence of R' is independently hydrogen or a protecting group; and wherein each occurrence of R" is independently hydrogen or a nitrogen protecting group.

13. The compound or glycoconjugate of claim 11, wherein A is the carbohydrate determinant Globo-H having the structure:



wherein each occurrence of R' is independently hydrogen or a protecting group, and wherein R" is hydrogen or a nitrogen protecting group.

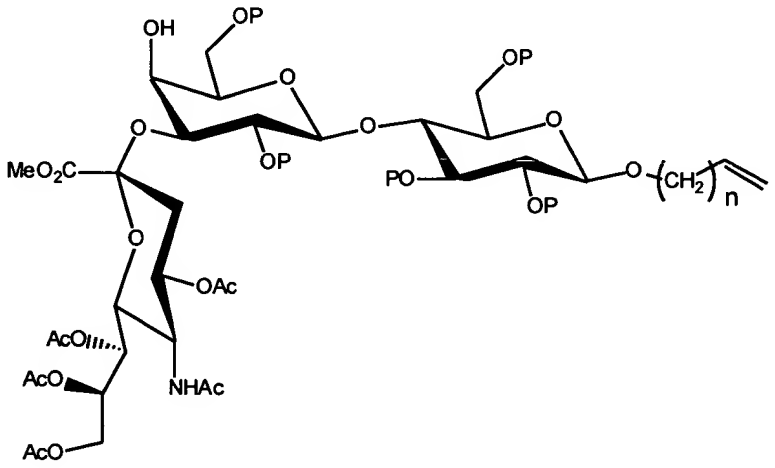
14. A method for the synthesis of complex carbohydrates comprising:

(a) providing a carbohydrate acceptor having a reducing end alkenyl group;

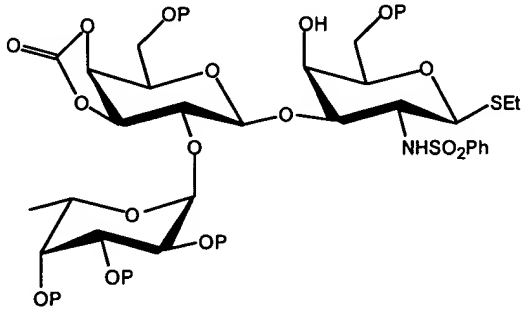
(b) providing a suitable donor compound; and

(c) coupling said donor and acceptor under conditions to generate an alkenyl glycoside.

15. The method of claim 14, wherein the step of providing a carbohydrate acceptor having a reducing end alkenyl group comprises providing an acceptor having the structure:

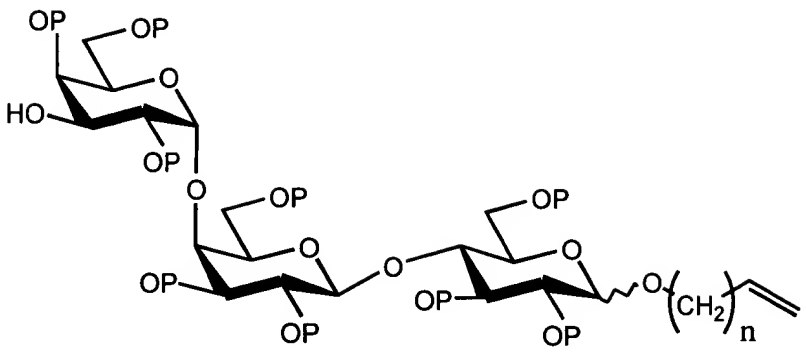


wherein P is a protecting group and n is 0-8, and wherein the step of providing a suitable donor compound comprising providing a donor having the structure:

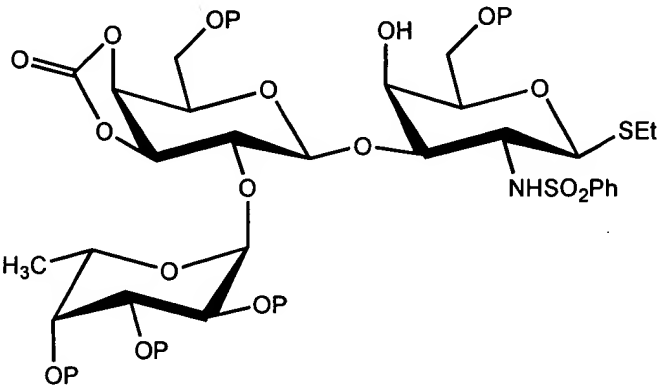


wherein n is 0-8, and wherein P is a protecting group.

16. The method of claim 14, wherein the step of providing a carbohydrate acceptor having a reducing end alkenyl group comprises providing an acceptor having the structure:



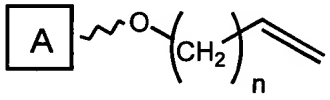
wherein P is a protecting group and n is 0-8, and wherein the step of providing a suitable donor compound comprising providing a donor having the structure:



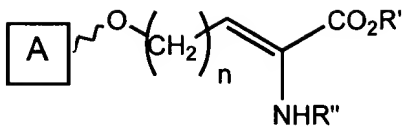
wherein n is 0-8 and P is a protecting group.

17. A method for the synthesis of a glycoamino acid comprising the steps of:

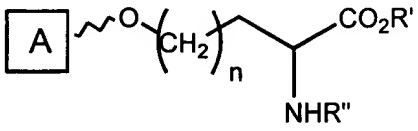
(a) providing an alkenyl glycoside having the structure:



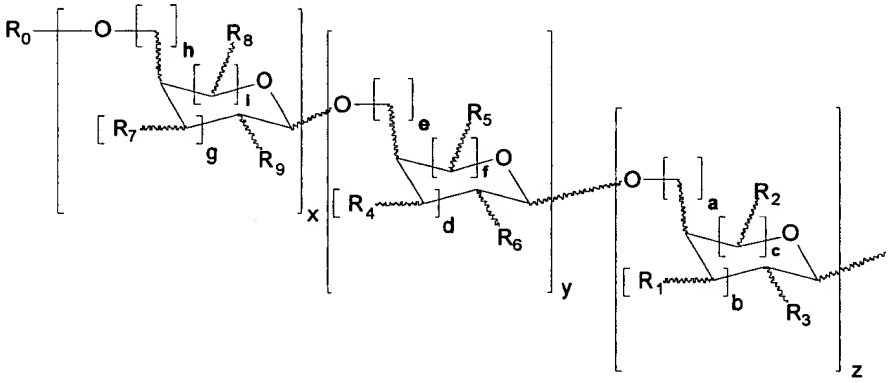
and reacting said alkenyl glycoside under suitable conditions to generate an enamide ester having the structure:



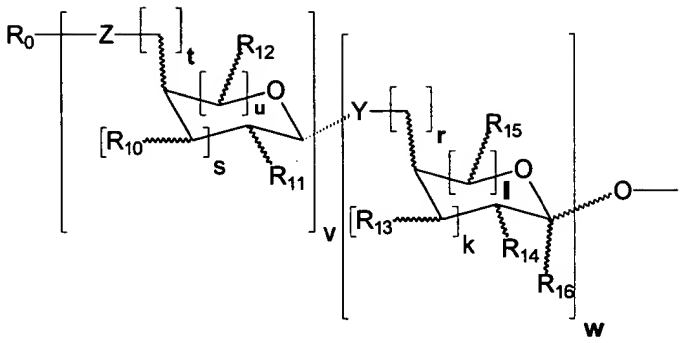
(b) reacting said enamide ester under suitable conditions to generate a glycoamino acid having the structure:



wherein, for each of the structures above, n is 0-8, wherein A is a carbohydrate domain having the structure:



wherein a, b, c, d, e, f, g, h, i, x, y and z are independently 0, 1, 2 or 3, with the proviso that x, y and z are not simultaneously 0; wherein R_0 is hydrogen, a linear or branched chain alkyl, acyl, arylalkyl or aryl group; wherein R_1, R_2, R_3, R_4 , R_5, R_6 , R_7, R_8 and R_9 are each independently hydrogen, OH, OR^i, NH_2, $NHCOR^i$, F, CH_2OH, CH_2OR^i, a substituted or unsubstituted linear or branched chain alkyl, (mono-, di- or tri)hydroxyalkyl, (mono-, di- or tri)acyloxyalkyl, arylalkyl or aryl group; wherein R^i is hydrogen, CHO, $COOR^{ii}$, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group or a saccharide moiety having the structure:

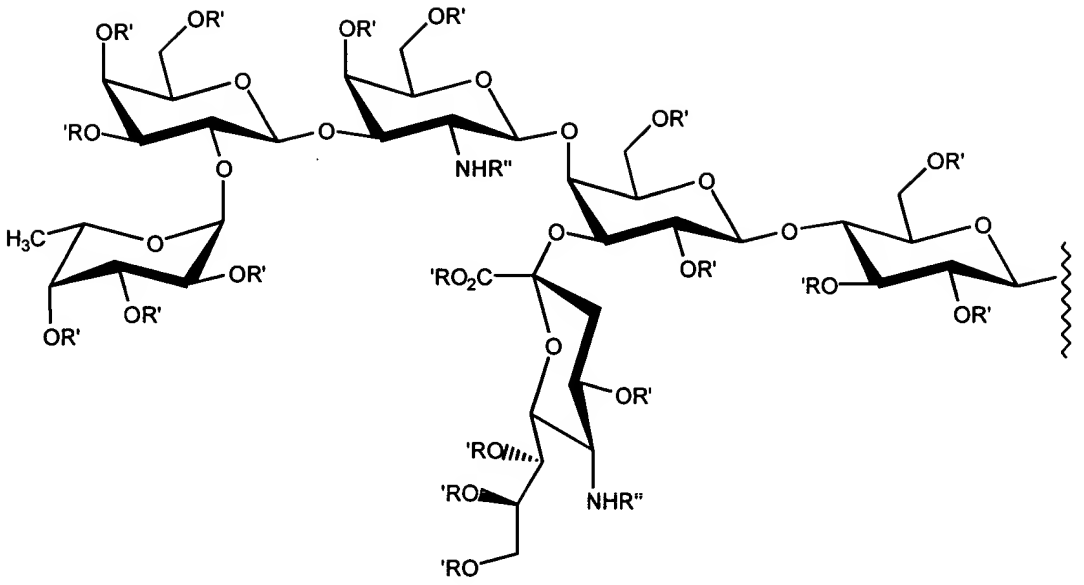


wherein Y and Z are independently NH or O; wherein k, l, r, s, t, u, v and w are each independently 0, 1 or 2; wherein R_{10}, R_{11}, R_{12}, R_{13}, R_{14} and R_{15} are each independently hydrogen, OH, OR^{iii}, NH_2, $NHCOR^{iii}$, F, CH_2OH, CH_2OR^{iii}, or a substituted or unsubstituted linear or branched chain alkyl, (mono-, di- or tri)hydroxyalkyl, (mono-, di- or tri)acyloxyalkyl, arylalkyl or aryl group; wherein R_{16} is hydrogen, COOH, $COOR^{ii}$, $CONHR^{ii}$, a substituted or unsubstituted linear or branched chain alkyl or aryl group; wherein R^{iii} is hydrogen, CHO, $COOR^{iv}$, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group; and wherein R^{ii} and R^{iv} are each independently H, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group;

and wherein for the glycoamino acid structure R' and R" are each independently protecting group or hydrogen.

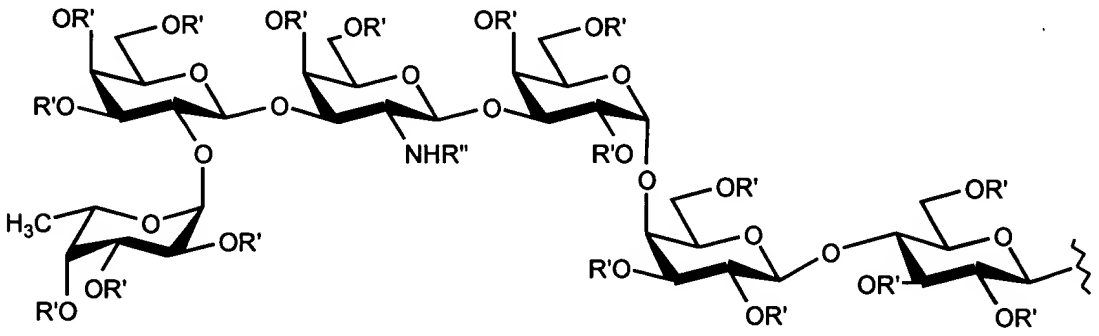
18. The method of claim 17, wherein the carbohydrate determinant is selected from the group consisting of Globo-H, fucosyl GM1, KH-1, glycophorin, STN, (2,3)ST, Le^y, N3, Tn, 2,6-STn, and TF.

19. The method of claim 18, wherein A is a carbohydrate determinant having the structure:



wherein each occurrence of R' is independently hydrogen or a protecting group; and wherein each occurrence of R" is independently hydrogen or a nitrogen protecting group.

20. The method of claim 18, wherein A is a carbohydrate determinant having the structure:



wherein each occurrence of R' is independently hydrogen or a protecting group, and wherein R" is hydrogen or a nitrogen protecting group.

21. The method of claim 17, wherein the step of reacting an alkenyl glycoside under suitable conditions to generate an enamide ester comprises reacting an alkenyl glycoside

first under oxidative cleavage conditions and second under olefination conditions in the presence of base and phosphonate to generate an enamide ester.

22. The method of claim 21, wherein said oxidative cleavage conditions comprise ozonolysis, and wherein the base is tetramethylguanidine.

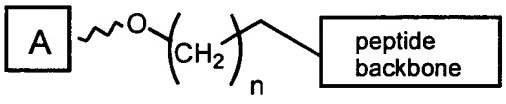
23. The method of claim 21, wherein said oxidative cleavage conditions are OsO_4 and periodate, or OsO_4 and $Pb(OAc)_4$, and wherein the base is lithium t-butoxide or lithium hexamethyl disilylazide.

24. The method of claim 17, wherein the step of reacting said enamide ester under suitable conditions to generate a glycoamino acid comprises reacting said enamide ester under hydrogenation conditions and subsequent reaction under deprotection conditions to generate a glycoamino acid.

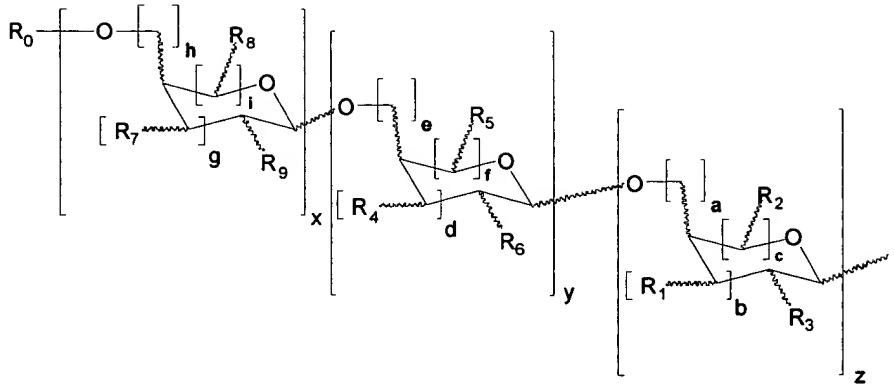
25. The method of claim 24, wherein said hydrogenation is achieved via asymmetric hydrogenation.

26. The method of claim 25, wherein said asymmetric hydrogenation is achieved by utilizing an ethyl DuPHOS catalyst precursor.

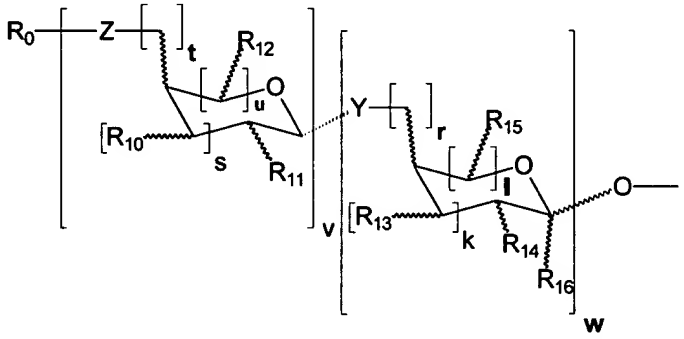
27. A multi-antigenic glycopeptide comprising a peptidic backbone made up of at least three amino acids, wherein one or more of said amino acids are substituted with an n-alkyl glycosidic moiety having the structure:



wherein each occurrence of A is a carbohydrate determinant having the structure:



wherein a, b, c, d, e, f, g, h, i, x, y and z are independently 0, 1, 2 or 3, with the proviso that x, y and z are not simultaneously 0; wherein R_0 is hydrogen, a linear or branched chain alkyl, acyl, arylalkyl or aryl group; wherein R_1, R_2, R_3, R_4 , R_5, R_6 , R_7, R_8 and R_9 are each independently hydrogen, OH, OR^i, NH_2, $NHCOR^i$, F, CH_2OH, CH_2OR^i, a substituted or unsubstituted linear or branched chain alkyl, (mono-, di- or tri)hydroxyalkyl, (mono-, di- or tri)acyloxyalkyl, arylalkyl or aryl group; wherein R^i is hydrogen, CHO, $COOR^{ii}$, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group or a saccharide moiety having the structure:

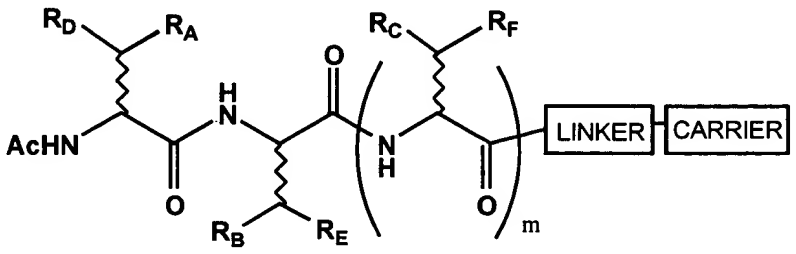


wherein Y and Z are independently NH or O; wherein k, l, r, s, t, u, v and w are each independently 0, 1 or 2; wherein R_{10}, R_{11}, R_{12}, R_{13}, R_{14} and R_{15} are each independently hydrogen, OH, OR^{iii}, NH_2, $NHCOR^{iii}$, F, CH_2OH, CH_2OR^{iii}, or a substituted or unsubstituted linear or branched chain alkyl, (mono-, di- or tri)hydroxyalkyl, (mono-, di- or tri)acyloxyalkyl, arylalkyl or aryl group; wherein R_{16} is hydrogen, COOH, $COOR^{ii}$, $CONHR^{ii}$, a substituted or unsubstituted linear or branched

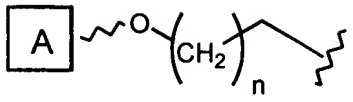
chain alkyl or aryl group; wherein R^{iii} is hydrogen, CHO, $COOR^{iv}$, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group; and wherein R^{ii} and R^{iv} are each independently H, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group;

wherein each occurrence of n is independently 0-8, whereby, if for each occurrence of n, n = 0, at least one occurrence of A has a different structure from other occurrences of A; and wherein the n-alkyl glycosidic moiety is either α- or β-linked to an amino acid.

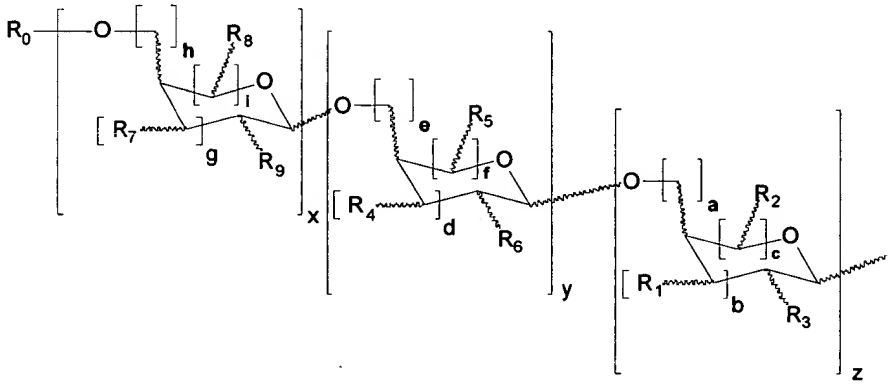
28. The glycopeptide of claim 27, wherein said glycopeptide is a construct having the structure:



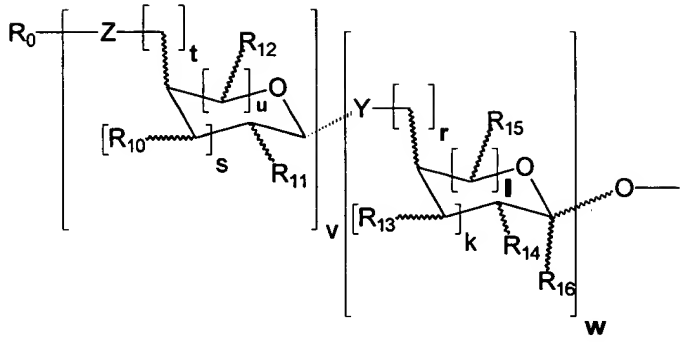
wherein the linker is either a free carboxylic acid, (carboxamido)alkyl carboxamide, MBS, primary carboxamide, mono- or dialkyl carboxamide, mono- or diarylcarboxamide, linear or branched chain (carboxy)alkyl carboxamide, linear or branched chain (alkoxycarbonyl)alkyl-carboxamide, linear or branched chain (carboxy)arylalkylcarboxamide, linear or branched chain (alkoxycarbonyl)alkylcarboxamide, an oligoester fragment comprising from 2 to about 20 hydroxy acyl residues, a peptidic fragment comprising from 2 to about 20 amino acyl residues, or a linear or branched chain alkyl or aryl carboxylic ester; wherein the carrier is a protein or lipid; wherein m is 1, 2 or 3; wherein R_A, R_B and R_C are each independently H or methyl; and wherein R_D, R_E and R_F are each independently an alkyl glycosidic moiety having the structure:



wherein each occurrence of A is independently selected from a carbohydrate domain having the structure:



wherein a, b, c, d, e, f, g, h, i, x, y and z are independently 0, 1, 2 or 3, with the proviso that x, y and z are not simultaneously 0; wherein the carbohydrate domain is linked to the respective amino acyl or hydroxy acyl residue by substitution of a side group substituent selected from the group consisting of OH, COOH and NH_2; wherein R_0 is hydrogen, a linear or branched chain alkyl, acyl, arylalkyl or aryl group; wherein R_1, R_2, R_3, R_4 , R_5, R_6 , R_7, R_8 and R_9 are each independently hydrogen, OH, OR^i, NH_2, $NHCOR^i$, F, CH_2OH, CH_2OR^i, a substituted or unsubstituted linear or branched chain alkyl, (mono-, di- or tri)hydroxyalkyl, (mono-, di- or tri)acyloxyalkyl, arylalkyl or aryl group; wherein R^i is hydrogen, CHO, $COOR^{ii}$, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group or a saccharide moiety having the structure:



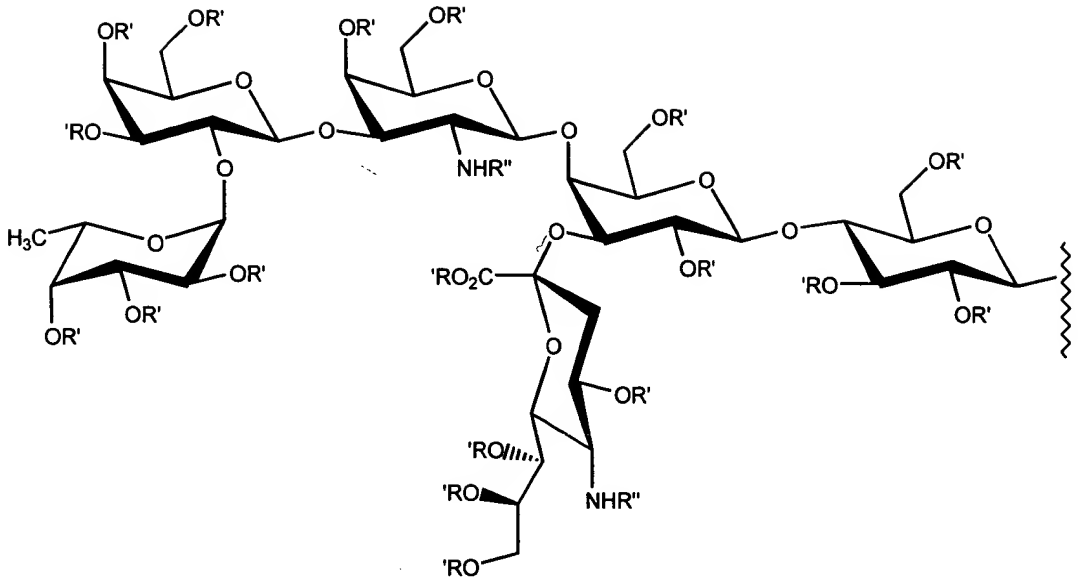
wherein Y and Z are independently NH or O; wherein k, l, r, s, t, u, v and w are each independently 0, 1 or 2; wherein R_{10}, R_{11}, R_{12}, R_{13}, R_{14} and R_{15} are each independently hydrogen, OH, OR^{iii}, NH_2, $NHCOR^{iii}$, F, CH_2OH, CH_2OR^{iii}, or a substituted or unsubstituted linear or branched chain alkyl, (mono-, di- or tri)hydroxyalkyl, (mono-, di- or tri)acyloxyalkyl, arylalkyl or aryl group; wherein R_{16} is hydrogen, COOH, $COOR^{ii}$, $CONHR^{ii}$, a substituted or unsubstituted linear or branched chain alkyl or aryl group; wherein R^{iii} is hydrogen, CHO, $COOR^{iv}$, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group; and wherein R^{ii} and R^{iv} are each independently H, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group; and

wherein each occurrence of n is independently 0-8, whereby, if for each occurrence of n, n = 0, at least one occurrence of A has a different structure from other occurrences of A; and wherein the n-alkyl glycosidic moiety is either α- or β-linked to an amino acid.

29. The compound of claim 27 or the construct of 28 , wherein each occurrence of A is independently Globo-H, fucosyl GM1, KH-1, glycophorin, Le^y, N3, Tn, 2,6-STn, (2,3)ST, or TF.

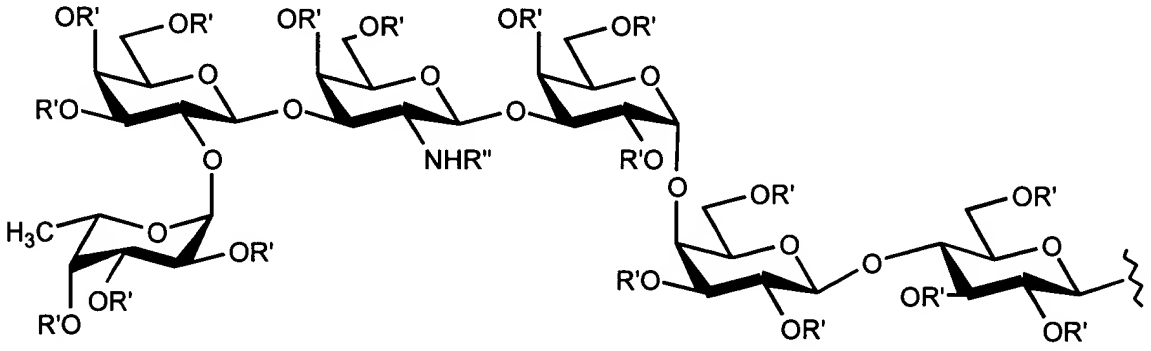
30. The construct of claim 28, wherein said compound has three occurrences of A comprising Tn, Globo-H and Le^y

31. The compound of claim 27 or the construct of claim 28, wherein at least one occurrence of A is a carbohydrate determinant having the structure:



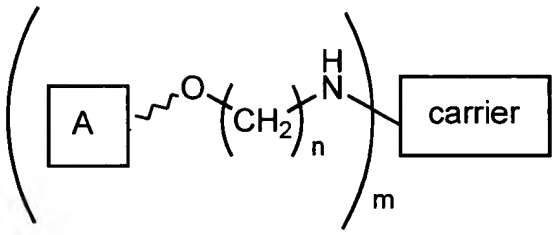
wherein each occurrence of R' is independently hydrogen or a protecting group; and wherein each occurrence of R" is independently hydrogen or a nitrogen protecting group.

32. The compound of claim 27 or the construct of claim 28, wherein at least one occurrence of A is a carbohydrate determinant having the structure:

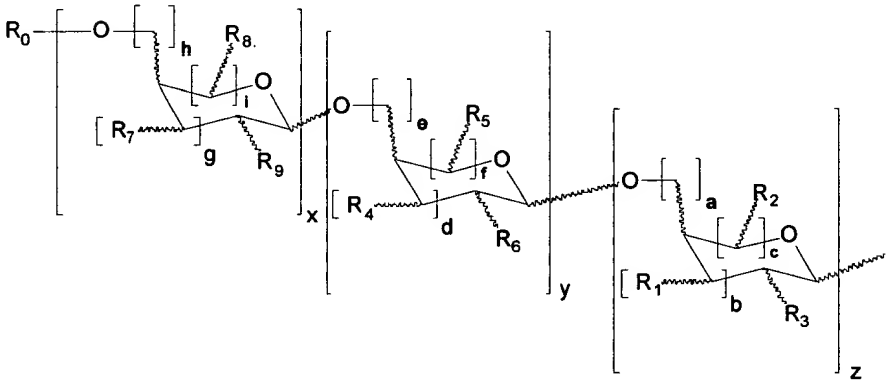


wherein each occurrence of R' is independently hydrogen or a protecting group; and wherein R" is hydrogen or a nitrogen protecting group.

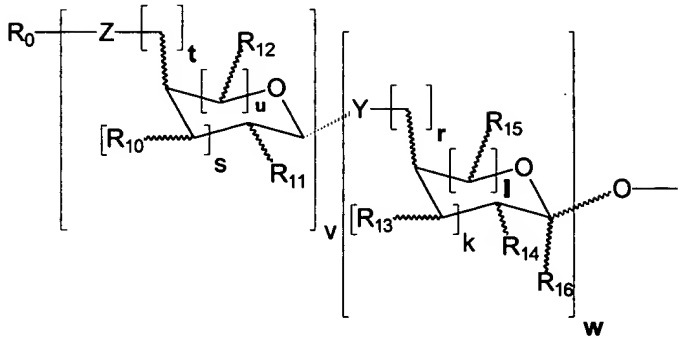
33. A synthetic construct having the structure:



wherein A is a carbohydrate domain having the structure:



wherein a, b, c, d, e, f, g, h, i, x, y and z are independently 0, 1, 2 or 3, with the proviso that x, y and z are not simultaneously 0; wherein R_0 is hydrogen, a linear or branched chain alkyl, acyl, arylalkyl or aryl group; wherein R_1, R_2, R_3, R_4 , R_5, R_6 , R_7, R_8 and R_9 are each independently hydrogen, OH, OR^i, NH_2, $NHCOR^i$, F, CH_2OH, CH_2OR^i, a substituted or unsubstituted linear or branched chain alkyl, (mono-, di- or tri)hydroxyalkyl, (mono-, di- or tri)acyloxyalkyl, arylalkyl or aryl group; wherein R^i is hydrogen, CHO, $COOR^{ii}$, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group or a saccharide moiety having the structure:



wherein Y and Z are independently NH or O; wherein k, l, r, s, t, u, v and w are each independently 0, 1 or 2; wherein R_{10}, R_{11}, R_{12}, R_{13}, R_{14} and R_{15} are each independently hydrogen, OH, OR^{iii}, NH_2, $NHCOR^{iii}$, F, CH_2OH, CH_2OR^{iii}, or a substituted or unsubstituted linear or branched chain alkyl, (mono-, di- or tri)hydroxyalkyl, (mono-, di- or tri)acyloxyalkyl, arylalkyl or aryl group; wherein R_{16} is hydrogen, COOH, $COOR^{ii}$, $CONHR^{ii}$, a substituted or unsubstituted linear or branched chain alkyl or aryl group; wherein R^{iii} is hydrogen, CHO, $COOR^{iv}$, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group; and wherein R^{ii} and R^{iv} are each independently H, or a substituted or unsubstituted linear or branched chain alkyl, arylalkyl or aryl group;

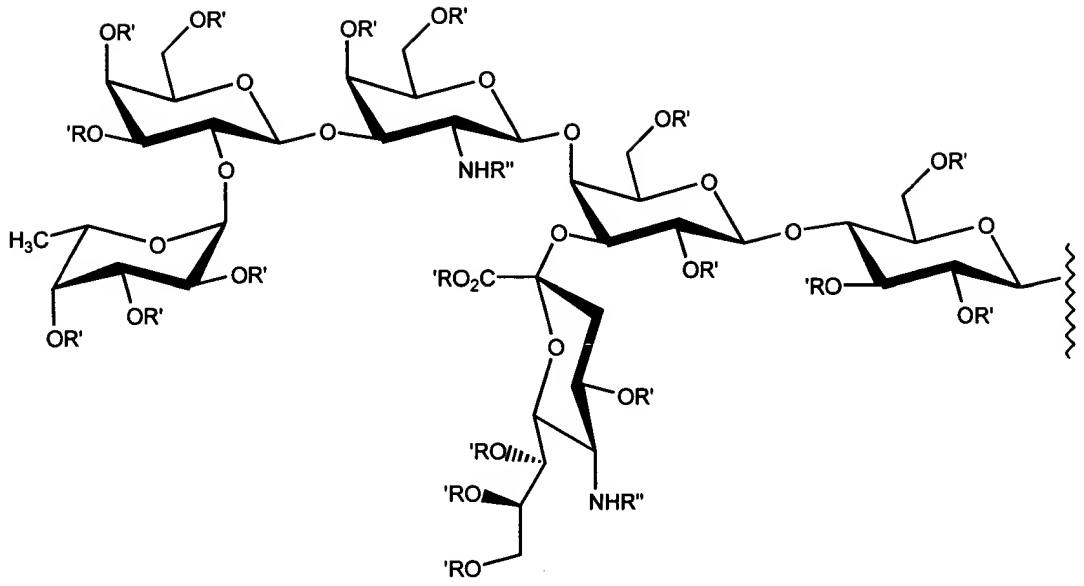
wherein n is 0-8; wherein the carrier a lipid or protein linked directly or through a crosslinker; and wherein m is in the range of 20 to 600.

34. The construct of claim 33, wherein m is in the range of 200 to 600.

35. The construct of claim 33, wherein n is 4.

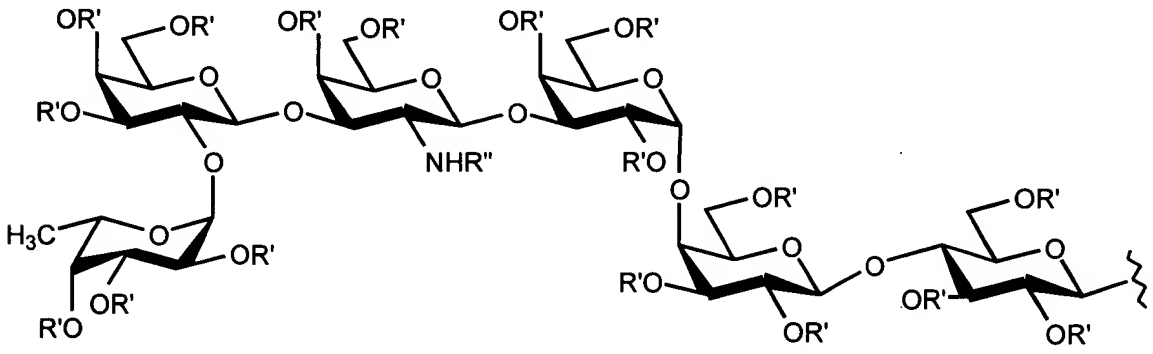
36. The construct of claim 33, wherein the carbohydrate determinant is selected from the group consisting of Globo-H, fucosyl GM1, KH-1, glycophorin, STN, (2,3)ST, 2,6-STn, N3, Tn, TF and Le^y.

37. The construct of claim ~~33 or 35~~, wherein A is a carbohydrate determinant, having the structure:



wherein each occurrence of R' is independently hydrogen or a protecting group; and wherein each occurrence of R" is independently hydrogen or a nitrogen protecting group.

38. The construct of claim 33 or 35, wherein A is a carbohydrate determinant, having the structure:



wherein each occurrence of R' is independently hydrogen or a protecting group; and wherein R" is hydrogen or a nitrogen protecting group.

39. A pharmaceutical composition comprising:
a compound or construct of claim 1 or 27, and
a pharmaceutically suitable carrier.

40. A method of treating cancer in a subject suffering therefrom comprising:
administering to a subject a therapeutically effective amount of a compound or construct of claim 1 or 27,
and a pharmaceutically suitable carrier.

41. The method of claim 40, wherein said method comprises preventing the recurrence of cancer in a subject.

42. The method of claim 40 or 41, further comprising co-administering one or more immunological adjuvants.

43. The method ~~of claim 42~~, wherein at least one of said one or more immunological adjuvants is a saponin adjuvant.

44. The method ~~of claim 43~~, wherein said saponin adjuvant is GPI-0100.

45. The method ~~of claim~~ 42, wherein at least one of said one or more immunological adjuvants is bacteria or liposomes.

46. The method ~~of claim 45~~, wherein the immunological adjuvant is Salmonella minnesota cells, bacille Calmette-Guerin or QS21.

47. The method of ~~claim~~ 40 or 41, wherein the cancer is a solid tumor.

48. The method of ~~claim 40~~ or 41, wherein the subject is in clinical remission, or where the subject has been treated by surgery, has limited unresected disease.

49. A method of inducing antibodies in a subject, wherein the antibodies are capable of specifically binding with tumor cells, which comprises administering to the subject an amount of a compound or construct of claim 1 or 27 effective to induce the antibodies.

50. The method ~~of claim 49~~, further comprising co-administering one or more immunological adjuvants.

51. The method ~~of claim~~ 50, wherein at least one of said one or more immunological adjuvants is a saponin adjuvant.

52. The method of claim 51, wherein said saponin adjuvant is GPI-0100.

53. The method of claim 49, wherein at least one of said one or more immunological adjuvants is bacteria or liposomes.

54. The method of ~~claim 53,~~ wherein the immunological adjuvant is *Salmonella minnesota* cells, bacille Calmette-Guerin or QS21.

55. The method of claim 49, wherein the subject is in clinical remission, or where the subject has been treated ~~by surgery~~, has limited unresected disease.